# PATENT COOPERATION TREATY

# PCT



## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

| Applicant's or agent's file reference<br>208320/EP/av | **FOR FURTHER ACTION** | See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416) |
|---|---|---|
| International application No.<br>PCT/NL 03/00566 | International filing date *(day/month/year)*<br>06.08.2003 | Priority date *(day/month/year)*<br>16.08.2002 |
| International Patent Classification (IPC) or both national classification and IPC<br>A61B3/107 | | |
| Applicant<br>UNIVERSITEIT MAASTRICHT | | |

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 8 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

| Date of submission of the demand | Date of completion of this report |
|---|---|
| 24.12.2003 | 29.10.2004 |
| Name and mailing address of the international preliminary examining authority:<br>European Patent Office - Gitschiner Str. 103<br>D-10958 Berlin<br>Tel. +49 30 25901 - 0<br>Fax: +49 30 25901 - 840 | Authorized Officer<br>Jonsson, P.O.<br>Telephone No. +49 30 25901-557 |

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NL 03/00566

## I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

**Description, Pages**

| | |
|---|---|
| 2, 3, 5-16 | as originally filed |
| 4 | received on 19.05.2004 with letter of 18.05.2004 |
| 1, 1a | received on 18.08.2004 with letter of 16.08.2004 |

**Claims, Numbers**

| | |
|---|---|
| 1-31 | received on 19.05.2004 with letter of 18.05.2004 |

**Drawings, Sheets**

| | |
|---|---|
| 1/5-5/5 | as originally filed |

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   *(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

## V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

| | | | |
|---|---|---|---|
| Novelty (N) | Yes: | Claims | 1-31 |
| | No: | Claims | |
| Inventive step (IS) | Yes: | Claims | 1-31 |
| | No: | Claims | |
| Industrial applicability (IA) | Yes: | Claims | 1-31 |
| | No: | Claims | |

2. Citations and explanations

   **see separate sheet**

**Re Item V**

**Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Reference is made to the following documents:

   **D1**: US-A-6 024 449;
   **D2**: WO 02 45578 A.

2. Novelty and Inventive Step, Art. 33(1)-(3) PCT:

2.1 Independent claims 1, 20:
Document **D1**, which is considered to represent the most relevant state of the art, discloses (see col. 4/l. 48 - col. 5/l. 34; col.7/l. 55 - col. 8/l. 3; col. 13/l. 66 - col. 14/l. 33 and figures 1,9) a method/arrangement for performing measurements of a topography of a surface, such as the topography of an eye surface (see title), wherein:
-an image is projected onto said surface from at least one projection source using projection means (col. 7/l. 55-61);
-at least a fraction of the light leaving the surface as a result of said projection is received using one or more receiving units (CCD camera 11 in video camera 7, see col. 7/l. 65 and fig. 1; CCD sensor 71 in fig. 9, ), and said measurement of said topology relates to surface mapping of said surface (see title);
-wherein said topography of the surface is determined by analysis of said fraction of light leaving the surface (see col. 14/l. 15-17, combination of elevation and temperature topography).

2.2 From this the subject-matter of claims 1,20 differs in that the fraction of light leaving the surface is comprised of light radiated by the surface due to thermal emission, and that said analysis for determining said topography is performed on said light radiated by the surface due to thermal emission.

2.3 The subject-matter of claims 1,20 is therefore new (Article 33(2) PCT).

2.4 The problem to be solved by the present invention may therefore be regarded as how to provide an enhanced method/arrangement of measuring topography of a surface while still leaving the surface undisturbed from the measurement itself.

2.5 The solution to this problem proposed in claims 1,20 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reason:

In **D1** an embodiment is disclosed which uses a fraction of the light leaving the surface comprised of light radiated by the surface due to thermal emission, see figure 9 in combination with col. 13/l. 65-col. 14/l. 33. In this embodiment however, the measurement is used to detect hot-spots, or regions of overtemperature, on the surface, see **D1**, col. 14/lines 6-11. No mention in **D1** of an improved surface topology can bee foreseen, and no steps/features enabling such an analysis can be found in **D1**.

Also **D2** discloses a method and arrangement for topography measurements using analysis of light leaving a surface, but in **D2** autofluorescence in relation to ultra-violet light is used, or an additional layer of fluorescein in relation to infra-red light. **D2** does not disclose the use of thermal radiation for surface topology measurements.

2.6 Claims 2-19 and 21-31 are dependent on claims 1,20 respectively and as such also meet the requirements of the PCT with respect to novelty and inventive step.

3. Industrial Application, Art. 33(1) and 33(4) PCT:
The industrial applicability (Art. 33(4) PCT) is clearly given for the subject-matter of all apparatus claims ("Arrangement for") as claimed in claims 20-31. However, it is noted that no unified criteria exists as regards industrial applicability of diagnostic methods. If the method claims 1-19 are maintained, this issue will therefore be the subject of further examination in a later regional/national phase.

4. In conclusion the Application fulfils the requirements of Art. 33(1) - 33(4) PCT

Title

Method and arrangement for performing measurements of the topography of a surface.

## Field of the Invention

The present invention relates to a method for performing measurements of a topography of a surface, such as the topography of an eye surface, wherein an image is projected onto said surface from at least one projection light source using projection means, wherein at least a fraction of light leaving the surface as a result of said projection is received using one or more receiving units, such as charged coupled device (CCD) based cameras, wherein measurement of said topography relates to surface mapping of said surface, wherein said topography of the surface is determined by analysis of said fraction of light leaving the surface, and wherein said fraction of light leaving the surface is comprised of light radiated by the surface due to thermal emission.

The invention further relates to an arrangement for performing measurements of the topography of a surface, such as topography of an eye surface, wherein measurement of said topography relates to surface mapping of said surface, said arrangement comprising projection means, which projection means comprise at least one projection light source for projecting an image onto the surface, further comprising one or more receiving units for receiving at least a fraction of light leaving the surface as a result of said projection, such as charged coupled device (CCD) based cameras, and means for analysis of said fraction of light leaving the surface for determining the topography of the surface.

## Background of the Invention

A method and arrangement of this type is for example

disclosed in U.S. patent nr. US 6,024,449, wherein a grid pattern of pulsed monochromatic polarized light is projected onto a semi-difuse target surface, such as the de-epithelialized cornea of an eye undergoing photo refractive keratometry (PRK) or photo therapeutic keratometry (PTK), for performing high speed topography measurements on said target. In addition, the method and arrangement disclosed include respectively enable measurement of regions of overtemperature (hot spots) on the target surface using a quantum well infrared photodetector.

Many industrial, scientific and medical processes involve the measurement of the topography of surfaces for variety of applications. In most cases the accuracy of the measurements is of great importance for the quality of the output of the process mentioned. A specific type of surface topography measurements involves the measurements of curved surfaces, as is applied, for example, in

96

Summary of the invention

It is an object of the present invention to provide a method and arrangement for performing measurements of the topography of a surface, such as an eye or corneal surface, which alleviates the problems described above and wherein the surface remains undisturbed, thus reducing the chance of disturbing measuring results by the measuring method itself.

These and other objects and advantages achieved by the present invention in that there is provided a method as described in claim 1.

Projecting the image using, for example, infra-red light provides several benefits. For this colour the eye is not only fully opaque, but the photons that are absorbed by, for instance, a tissue are converted into heat. This heat causes thermal excitation of the matter in the tissue generating radiation comprising wavelengths other than the original wavelength that was projected onto the surface. The light that is not absorbed by the tissue, but may instead be reflected back to the receiving unit (specular reflection, scattering), is still comprised of its original wavelength. This natural process enables filtering of the reflected light from the signal by for example an optical filter or dichroic mirror, leaving only the fraction of light caused by thermal emission to be detected by the detection means. It will be appreciated

CLAIMS

1. Method for performing measurements of a topography of a surface, such as the topography of an eye surface, wherein an image is projected onto said surface from at least one projection light source using projection means, wherein at least a fraction of light leaving the surface as a result of said projection is received using one or more receiving units, such as charged coupled device (CCD) based cameras, wherein measurement of said topography relates to surface mapping of said surface, wherein said topography of the surface is determined by analysis of said fraction of light leaving the surface, and wherein said fraction of light leaving the surface is comprised of light radiated by the surface due to thermal emission, characterised in that, said analysis for determining said topography of the surface is performed on said light radiated by the surface due to thermal emission.

2. Method according to claim 1, wherein at least one of the receiving units only receives said fraction of light leaving the surface during thermal excitation of the surface.

3. Method according to any of the previous claims, wherein said fraction of the light leaving the surface further comprises excitation light that is radiated by the surface due to excitation of surface matter, and wherein said excitation light is removed before said analysis of said fraction of light leaving the surface.

4. Method according to any of the previous claims, wherein the surface is at least part of the surface of a human or animal eye.

5. Method according to any of the previous claims, wherein the image projected onto the surface is projected with light comprising a colour for which the surface is opaque.

6. Method according to claim 5, wherein said colour for which the surface is opaque corresponds to a colour of infrared (IR) light.

7. Method according to claim 6, wherein mid-IR light is used

for projecting said image on the surface.

8. Method according to any of the previous claims, wherein said projection means flashes the image onto the surface, and wherein at least one of said receiving units is synchronised with said projection means.

9. Method according to claim 8, wherein said projection means projects the image during a series of flashes onto the surface, enabling determination of dynamics of the topography of the surface.

10. Method according to any of the claims 7 and 8, wherein said fraction of the light leaving the surface comprises excitation light that is radiated by the surface due to excitation of surface matter, and wherein said excitation light is used to synchronise the at least one of said receiving units.

11. Method according to any of the previous claims, wherein illumination of the surface by an ambient light source enables detection of references on or underneath the surface using said one or more receiving units.

12. Method according to claim 11, wherein said ambient light source radiates light of a colour for which the surface is at least partly transparent.

13. Method according to any of the claims 11 and 12, wherein the surface is at least part of an eye surface, and wherein the light radiated by said ambient light source is near-IR light.

14. Method according to any of the previous claims, wherein a plurality of receiving units are used for receiving said fraction of light leaving the surface, wherein said receiving units are arranged for receiving a desired image of said fraction of light at a fixed distance from said surface, and wherein placing the surface at said fixed distance for receiving the desired image at least comprises the steps of:

- projecting a plurality of references onto the surface along an optical path using reference projection means, which references

are projected such that at least one of the optical paths of said reference projection means is at an angle with at least one other of said optical paths of the reference projection means, and such that if the references are projected on the surface at said fixed distance to the receiving units, a recognisable pattern is formed on the surface by said references,

- adjusting the distance between surface and receiving units such that said references form said recognisable pattern on the surface.

15. Method according to claim 14, wherein near-IR light is used for projecting said references onto the surface.

16. Method according to any of claims 14 and 15, wherein the surface is an eye surface comprising a corneal surface, and wherein pupil, iris and conjunctiva are comprised underneath said surface, and wherein said more than one reference is projected onto a region of the conjunctiva outside a region of the corneal surface.

17. Method according to any of the previous claims, wherein said image projected onto the surface is an interference pattern provided by any of a group of a grid, a slit, a double slit, an interferometer, and other means for creating an interference pattern.

18. Method according to claim 17, wherein said interference pattern used is a sinus shaped fringe pattern.

19. Method according to any of the previous claims, wherein a Moiré method, Fourier analysis methods or other profilometric methods are used for determining the topography of the surface.

20. Arrangement for performing measurements of the topography of a surface, such as topography of an eye surface, wherein measurement of said topography relates to surface mapping of said surface, said arrangement comprising projection means, which projection means comprise at least one projection light source for projecting an image onto the surface, further comprising one or more receiving units for receiving at

least a fraction of light leaving the surface as a result of said projection, such as charged coupled device (CCD) based cameras, and means for analysis of said fraction of light leaving the surface for determining the topography of the surface, characterised in that, said analysis means for determining the topography of the surface are arranged for analysing light radiated by the surface due to thermal emission.

21. Arrangement according to claim 20, further comprising filtering means for filtering said fraction of light leaving said surface, said filtering means being arranged for transmission of light that is radiated by the surface due to thermal excitation.

22. Arrangement according to any of the claims 20 and 21, wherein said projection means are arranged for flashing said image onto said surface.

23. Arrangement according to any of the claims 22, comprising means for limiting a period of time for which at least one of said receiving units receives said fraction of light leaving the surface such that said period of time is approximately the duration of thermal emission as a result of said flashed image on said surface.

24. Arrangement according to any of the claims 20-23, wherein said projection light source emits light of a colour for which the surface is opaque.

25. Arrangement according to claim 24, wherein said colour for which the surface is opaque corresponds to a colour of infrared (IR) light.

26. Arrangement according to claim 25, wherein mid-IR light is used for projecting said image on the surface.

27. Arrangement according to any of the claims 20-26, comprising means for synchronising said receiving units with said projection means.

28. Arrangement according to any of the claims 20-27, further comprising an ambient light source and means for detecting references on

said surface.

29. Arrangement according to claim 28, wherein said ambient light source comprises a near-IR light source.

30. Arrangement according to any of the claims 20-29, comprising a plurality of receiving units, and further comprising means for projecting more than one reference onto the surface, and means for constructing a composite image from images received by said receiving units.

31. Arrangement according to any of the claims 20-30, wherein said projecting means comprises means for projecting an interference pattern onto said surface.